1221-8

CONCRETE GRANDSTANDS

PORTLAND CEMENT ASSOCIATION

CONCRETE GRANDSTANDS

Concrete for Permanence

Published by

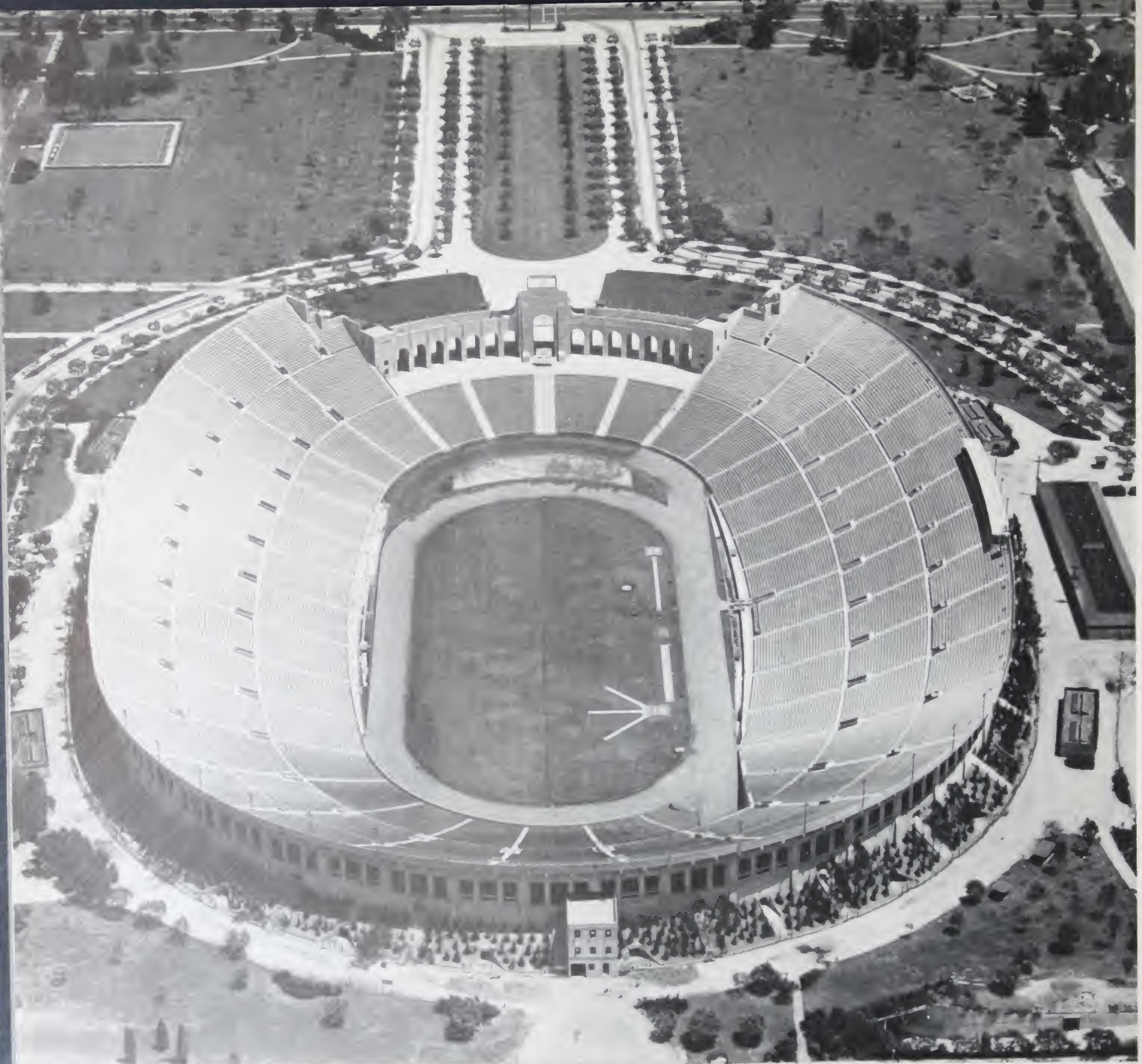
PORTLAND CEMENT ASSOCIATION

33 West Grand Avenue, Chicago, Illinois

ILLINOIS MEMORIAL STADIUM, MOOSEHEART, ILL.

The versatility of architectural concrete is revealed in these attractive walls in which the horizontality of the design is emphasized by the rustication. Likewise the fenestration is well integrated with the design as a whole and becomes a decorative feature. The impressive buttresses at the main entrance mark the passages through which one reaches the seating arena. F. D. Kay, architect.

TABLE OF CONTENTS



© Spence Air Photos

Olympic Stadium, Los Angeles, Calif. The bowl shape has been used for a number of the larger stadiums. John and Donald B. Parkinson, architects.

Kansas University, Lawrence, Kan. The horseshoe shape structure has also been popular for the large stadium. Clement C. Williams and L. H. Dodd, engineers.

INTRODUCTION

No longer is a modern permanent grandstand a luxury to be enjoyed only by the large university or large municipality. Today it is a necessary part of the athletic plant of every college and high school. Sports are definitely recognized as an essential part of the educational curriculum, and sports always rightly command an audience.

A grandstand also aids in the development of civic interest. Here the students, alumni, parents, friends and civic leaders can gather and enjoy a feeling of participation in the accomplishments of the local teams. Here friendly rivalry can be enjoyed by all. When the field and stands are not in use for school purposes, the municipality has available an outdoor recreation center for pageants and civic celebrations. Here honors can be properly paid to visiting dignitaries among favorable surroundings. An adequate place is provided for festivals and concerts to the delight of the entire community. A center of community interest is established. A grandstand is an essential asset for every community—an outstanding American institution.

Usually the structural design of grandstands is not a difficult problem for the engineer. However, proper details are important. A large part of this booklet is devoted to the exposition of features which have been found to give the best results under working conditions. Also discussed are cost, financing, size, shape, location and facilities. Consideration is given to the requirements of both the performer and the patron.

The material in this booklet is intended primarily to cover small and medium size grandstands for schools and municipalities where the principal athletic events will be football or baseball. However, much of the material is applicable to grandstands of any size used for any purpose.

Attractive Grandstands With Minimum Maintenance

Grandstands are continuously exposed to weather, the destructive forces of wetting and drying, freezing and thawing. It is desirable that they be so built that little maintenance will be required to keep them shipshape even under these severe conditions. They must, of course, be safe against damage or collapse when subject to the uncontrollable shocks caused by crowds of excited spectators. They should also be fire-resistant.

Concrete is, therefore, most often chosen for grandstands because it is relatively low in first cost, has the ability to withstand weathering with the minimum of maintenance, is firesafe, and has a tremendous reserve of strength. Beauty may be combined with its utility, since concrete lends itself so readily to architectural treatment. Improvements in form construction and in the methods of making, placing and finishing concrete have transformed it from a structural material only to one that is being used both structurally and architecturally. The illustrations in this book show only a few examples of its possibilities as an architectural medium. Outside walls may be made as elaborate or simple as desired. Entrances may be featured with appropriate details, and concrete enclosure fences of suitable design to harmonize with the main structure may be added to complete the project.

COST

One of the first subjects which come up for discussion in connection with the construction of permanent grandstands is their cost. The cost of the complete project is affected by a multitude of items including: condition of site—necessary grading, draining, conditioning of playing field, access drives and walks, fences, public utilities and foundation conditions; size and shape of grandstand; facilities provided—team rooms, public rest rooms, offices and concessions; architectural treatment; and local cost of materials and labor. For this reason, general figures on cost can have little value. However, as a rough approximation the cost of the seats and supporting structure only may be estimated at about \$6 to \$10 a seat.

Concrete may be used with any style of architecture. Gothic details are used in the University of Tulsa Stadium, Tulsa, Okla. Note flag poles attached to outside of walls and light poles supported on rear of structure. Leon B. Senter, architect.

FINANCING

Where there is need for a grandstand, the financing of the project should not be difficult. The size and cost of the structure may be suited to the local requirements so that admission charges will make it self-sustaining and self-liquidating where desired. In some cases, of course, grandstands are desired where no income will be available from entrance fees. These are usually the very small stands at public playgrounds, swimming pools or similar locations, and their construction is paid for from general funds, or recreation or park appropriations.

Many methods of financing have been used. A large part of the public as well as many educators are of the opinion that athletics are now such an essential part of a well rounded curriculum that provision for athletic structures, including a grandstand as an integral part of the school plant, is justifiable. In such cases the grandstand is built with funds appropriated by the school board or the municipality. On the other hand it may be necessary to finance the project by public subscription, by the sale of securities and by bank loans, or by a combination of these methods. Where public participation is necessary to raise all or a part of the funds, it is essential that a well developed campaign be carried on by influential people and enthusiasts for the project.

The first step in a campaign is the organization of a promotion committee. A small group of alumni, school officials and other citizens may prevail upon the civic organizations to appoint representatives to such a committee. The committee may incorporate an association as a nonprofit organization with the power to lease land, to contract for the construction of the grandstand and to finance the project. Working capital may be raised by donations from a few individuals or by the advance sale of season tickets. In some cases working capital has been provided by the athletic association where such funds have been previously built up.

The committee must study the requirements of the situation to determine the size of the project. An engineer or architect is employed to prepare preliminary plans and sketches for estimating the cost and for use in campaign publicity.

In one city of 25,000 population a local organization called the stadium corporation was incorporated under state law with the management in the hands of a stadium commission composed of 11 members with two members representing each of the active civic organizations, the chamber of commerce, Kiwanis, Lions and Rotary clubs, and three representing the board of education. The board of education granted to the corporation a 99-year lease for the ground. The corporation built and is operating the grandstand.

As a means of securing working capital about $5,000 was raised by selling season tickets in advance. These were sold by members of the organizations represented on the commission. Bonds for the construction were then issued and sold locally. One-half of all admission receipts is credited to an athletic fund to cover current expenses of the teams and other running expenses. The other half is credited to the corporation and is used to pay interest, to retire bonds and to cover incidental expenses. When all bonds are retired the lease will be surrendered to the board of education and the stadium will become its property.

A well organized campaign for raising funds may be conducted by dividing the workers into teams, each under the leadership of a captain who is a member of the committee or who is selected for his executive ability and influence in the community. Each team may be allotted a given quota and prizes awarded for the team reaching its goal first or raising the largest total amount. Usually prizes are donated by business people for the advertising derived. Lists of the alumni should be made available for solicitation. Local business people, always interested in local improvements, can be depended upon to boost the project and help financially. Civic organizations will take an active part by furnishing workers to solicit their own membership and others.

A large portion of the cost of the stadium at Mooseheart, Ill., was raised by donations equal to the estimated cost per seat. Bronze name plates were set in the concrete as a permanent record of the subscribers.

Publicity is an important activity in a campaign to raise funds. The committee should have at least one representative who is experienced in this field to take charge. Newspapers will cooperate on such projects and their publicity may be supplemented by attractively designed posters and direct mail pieces. The posters may be prepared by students as an art project. Benefit parties such as dances and card parties, and plays, exhibition games and similar entertainments are helpful in raising funds and also assist in publicity. Such affairs may be conducted by each of the organizations participating in the campaign.

THE PROJECT

Size

If the grandstand is to be built in connection with a school, the number of students, faculty, alumni and local townspeople should be considered. The popularity of the school, its athletic relations with other schools and the proximity to other towns and cities will influence the size. For community projects, careful consideration must be given to the drawing power of the events intended to be held.

Funds available may determine the size of a grandstand. Often where funds are limited, a section of the structure is built with a view to enlarging it later. Plans prepared for the complete project are helpful in creating interest and raising funds for the first section. In some cases larger structures than necessary have been built. They are, of course, a waste of funds. Where there is considerable uncertainty as to the proper size for a given project, construction of a grandstand section which can be easily enlarged has many advantages.

A survey of high school grandstands built in communities up to 50,000 population indicates that the ratio of the seating capacity to the population is larger for the smaller communities. In towns of 5,000 population, this ratio may be 25 per cent or more while in communities of 50,000, a ratio of 10 per cent appears to be conservative. Using these percentages the structures would have 1,250 seats in the one case and 5,000 seats in the other. As mentioned above, local conditions will affect these suggestions. Examples can be cited of places of 30,000 population or more having grandstands with seating capacities of 25 to 30 per cent of the population but these would appear to be special cases rather than representative of the average.

Shape

Many factors will affect the general shape of the structure. A straight or slightly curved stand is suitable for football, track and general entertainments. For large seating capacities, two such stands can be erected on opposite sides of the playing field and where necessary, curved sections connecting the side stands can be added to one or both ends. Balconies have been used in a few instances to provide the largest possible percentage of seats on the two sides of the playing field. In the case of football, observations of crowds free to choose their own seats show a preponderance of the spectators opposite the centerlines and in the lower rows. Some stands intended primarily for football have therefore been made much deeper at the center than at the ends. Grandstands for baseball are built on two sides of the diamond with bleacher stands bordering the outfield where necessary for added capacity.

Grandstands for a combination of uses are often desired. The combination of football and track has proved very satisfactory but a combination of such uses as baseball and football requires a compromise to the disadvantage of one or the other. Baseball grandstands have been used for football by laying out the field with the length nearly parallel to one side of the grandstand. Football grandstands built on one side of the field have been used for baseball by placing the diamond with the first base line practically parallel to the grandstand.

At Chelsea, Mass., this simple concrete stand was built opposite a larger concrete grandstand, under which are the facilities for players and spectators. Entrance is directly from the field. Feer & Eisenberg, architects.

Baseball grandstand at Westfield, Mass. R. P. Boyle, engineer. In small structures such as this, entrance from the field is satisfactory and economical.

Location

Athletic fields should be readily accessible to players and spectators. Ample facilities for parking automobiles within easy walking distance of the entrances are highly desirable. At the same time the parking should interfere as little as possible with the flow of traffic.

Facilities

The facilities to be provided will depend on the size of the grandstand, the purpose for which it is to be built, the proximity to other structures and the funds available. While a small grandstand may consist of no more than the actual seating structure, the larger stadiums include many special features. Grandstands built adjacent to school or other buildings used for athletic events may not require dressing accommodations for the teams if such accommodations are available in the buildings, but in other locations suitable dressing, locker and shower rooms should be included or provision made for their addition as soon as funds are available. Toilet facilities for both participants and spectators should always be provided unless available in adjacent buildings. On the larger projects, the facilities may also include ticket offices and other office space, information, refreshment, press and radio booths. Detailed suggestions on facilities are discussed on page 20.

Albany, Ga., has this combination football and baseball grandstand seating 6,000 people. Due to the hillside location, entrance is from the top. Offices and dressing rooms are provided under end sections. The curved front is a compromise to adapt the stand to both baseball and football. Rayburn S. Webb, architect; John Lowe, engineer.

The Foreman Field Stadium at Norfolk, Va., illustrates the concentration of seats near the center of action. C. A. Neff, architect; C. J. Lindeman, engineer.

DESIGN DETAILS

Orientation of Athletic Fields

A single misplay may mean the loss of an important game, and such a misplay may be caused by the glare of the sun's rays in the player's eyes. In planning an athletic field, therefore, one of the first considerations must be orientation of the various fields of play with respect to direction of the sun's rays. Studies of ideal orientation may determine the choice of the site for an athletic field where more than one site is under consideration and such studies are of value in locating the seating structures to best advantage. Other considerations may make it impossible to obtain ideal orientation but it is important to know what the ideal direction would be and adopt a layout as close to this as possible.

The direction of play in football is generally in lines parallel to the long axis of the field. The football season is short, usually October and November, and games are generally from about 2:00 to 4:00 in the afternoon, so that ideal orientation of football fields can be accurately determined. Main consideration should be for the players as spectators welcome the sun's rays at this time of year.

For baseball, conditions are generally considered most desirable when the sun's rays are parallel to the line joining first and third base. Two positions of the diamond will meet this requirement. The season for baseball is longer and warmer than for football and for the professional leagues at least, the spectators are given more consideration in selecting the orientation. Spectators generally prefer to sit along the first base line with the sun at their backs.

Maps have been published from which the ideal orientation of football fields and baseball diamonds in any part of the United States can be determined easily*. These show that for the center of the time zones, the short axis of football fields should be at an angle of about 50 deg. east of true north. Similarly the line from first to third base of baseball diamonds should be at an angle of about 72 deg. east of true north for projects located near the center of the time zones. These angles increase toward the east and south of the center of each zone and decrease toward the west and north of the center by a maximum of about 8 deg.

Sight Lines

The principal purpose of a grandstand is to provide the public with a good view of the performance under comfortable circumstances. The view is affected both by the distance to the action and by any obstruction to the sight line. The sight line is the straight line between the observer's eye and the object.

The center of action for football is at the center of the gridiron and that for baseball at the center of the diamond. In football it is particularly noticeable that with unreserved seats the patrons choose seats as near the center of action as possible. This results in the outside edge of the crowd forming an approximate arc with the center on the 50-yd. line**. Several grandstands have been built with the back conforming roughly to this arc.

Sight lines are generally considered only normal to

*"The Orientation of Athletic Fields" by Gavin Hadden, *American City*, May, 1928, Vol. 38, No. 5, page 138.

**"Influence of Loci on Engineering Design" by Gavin Hadden, *Civil Engineering*, December, 1934, Vol. 4, No. 12, page 632.

the stand, the oblique lines to different parts of the field being neglected. Some stands, particularly large bowls, have been built with a curved front so that the normal line approaches the line to the center of action. The additional complexity and cost of design and construction of such curved structures is not justified with small stands.

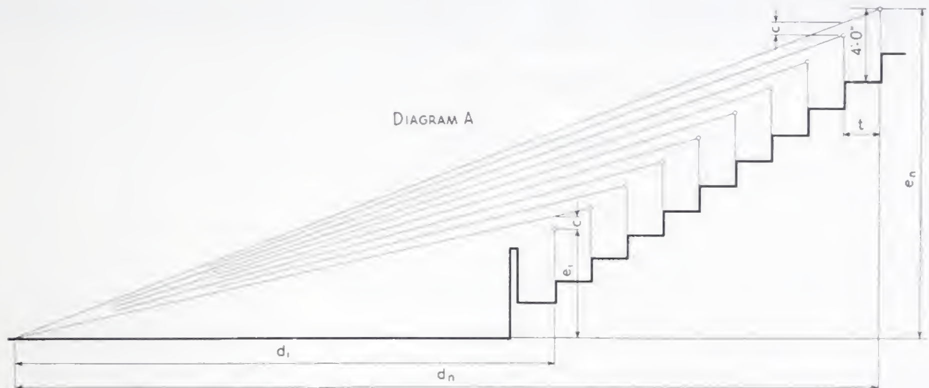
For the best view, there should be no obstruction between the spectator's eye and any part of the field of action. This requires that the sight line to any part of the field should be above the spectators in front. It is commonly assumed that for a seated spectator the eye is 4 ft. above the floor and 6 in. below the top of his hat. Naturally these distances vary considerably with different individuals so that too great refinement in determining sight lines is not warranted when the original assumptions at best can be only approximate.

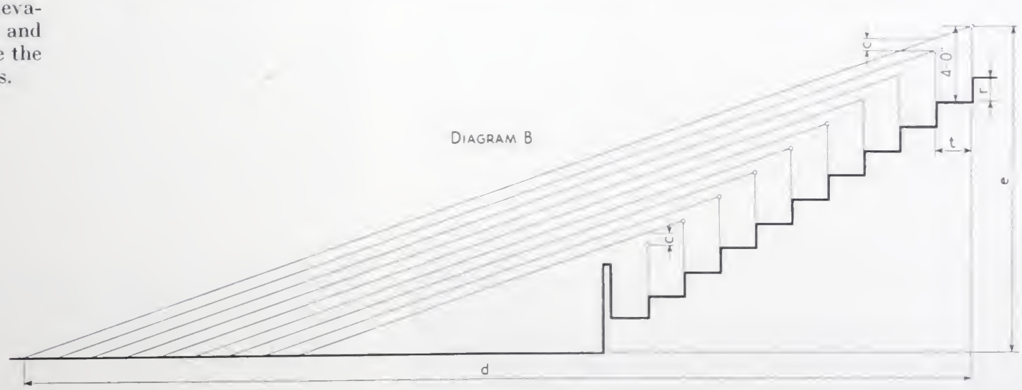
With a given focal point and elevation of the first seat, the required elevation of the other seats is materially affected by the assumed value of *c* (the clearance between successive sight lines). As previously stated, for unobstructed view the value of *c* should be 6 in., the assumed distance between eye and top of hat. However, except for small grandstands, this will frequently require the rear seats to be at an excessively high elevation. Many grandstands, in fact practically all large ones, have been built on the basis of a smaller value of *c*. While this smaller value has generally been dictated by the practical consideration of keeping the structure at a reasonable height, it seems justifiable to assume that spectators will have a satisfactory view if they can look over the heads of those in the second row ahead of them. This can be done if a value of 3 in. is used for *c*.

The focal point is the intersection of the sight line with the playing field or other object of interest. For football the focal point should be at about the nearest line of the playing field. For track, it should be at about chest height for a runner in the closest lane. For baseball, it should be the catcher. If these points of interest are beyond the focal points for all seats computed on basis of *c* equal to 3 in. the view will be satisfactory, particularly since a large part of the action will occur at points where the computed value of *c* will be larger.

If the focal point for all seats is made the same, a section through the seat deck will be a curve as shown in Diagram A. Diagram B shows the sight lines for a straight section in which the first and last seats and the clearance, *c*, are the same as in Diagram A. With this straight section, the focal point is different for each row but the average is approximately the same as the focal point for the ideal curved section. In other words, with the straight section the lower seats have better visibility and the upper seats poorer visibility than those in the curved section, but the average is the same.

Since with a straight section the top seat has the poorest view, it is necessary to check only this seat in order to determine that all seats are satisfactory. The relation between distance from seat to its focal point, *d*, height





Sight line diagrams. Diagram A shows a curved seat section with common focal point. Diagram B shows straight seat section with variable focal points. The elevation of front and rear seats and the sight line clearance are the same for the two diagrams.

of the eye above focal point, e, width of tread, t, height of riser, r, and clearance, c, is represented by the simple formula $\frac{d}{e} = \frac{t}{r-c}$.

For a curved section the relation of the various factors are represented by the formula

$$e_n = d_n \left[\frac{e_1}{d_1} + \frac{c}{t} \left(S_n - S_1\right) \right]^*$$

in which e_n = elevation above focal point of eye of spectator in row n.
e_1 = elevation above focal point of eye of spectator in row 1.
d_n = distance from focal point to row n.
d_1 = distance from focal point to row 1.
c = clearance between successive sight lines.
t = width of tread.
S_1 and S_n = values from table corresponding to $\frac{d_1}{t}$ and $\frac{d_n}{t}$. For simplicity the value of d_1 should be an exact multiple of t.

As an example of the use of this formula, assume that it is desired to design a grandstand with a common focal point but otherwise approximately the same as that shown on page 24. Assume the factors: $e_1 = 6$ ft., $d_1 = 32$ ft., $c = 0.25$ ft., $t = 2$ ft. Then the formula becomes

$$e_n = d_n \left[\frac{6}{32} + \frac{0.25}{2} \left(S_n - 3.3182\right) \right]$$

which can be simplified to $e_n = d_n\ (0.125S_n - 0.2273)$ for these specific conditions. For the last row $d_n = 78$; $\frac{d_n}{t} = 39$; from the table, $S_n = 4.2279$; and the formula gives $e_n = 23.494$ which is the distance above the focal point of eye of spectator in the last row. The elevation of the tread used by this spectator is then $23.49 - 4.0 = 19.49$. The elevation of each row is obtained similarly.

VALUES OF S

$\frac{d}{t}$	S	$\frac{d}{t}$	S	$\frac{d}{t}$	S
1	0.0000	36	4.1468	71	4.8328
2	1.0000	37	4.1746	72	4.8469
3	1.5000	38	4.2016	73	4.8608
4	1.8333	39	4.2279	74	4.8745
5	2.0833	40	4.2535	75	4.8880
6	2.2833	41	4.2785	76	4.9014
7	2.4500	42	4.3029	77	4.9145
8	2.5929	43	4.3267	78	4.9275
9	2.7179	44	4.3500	79	4.9403
10	2.8290	45	4.3727	80	4.9530
11	2.9290	46	4.3949	81	4.9655
12	3.0199	47	4.4167	82	4.9778
13	3.1032	48	4.4380	83	4.9900
14	3.1801	49	4.4588	84	5.0021
15	3.2516	50	4.4792	85	5.0140
16	3.3182	51	4.4992	86	5.0257
17	3.3807	52	4.5188	87	5.0374
18	3.4396	53	4.5380	88	5.0489
19	3.4951	54	4.5569	89	5.0602
20	3.5477	55	4.5754	90	5.0715
21	3.5977	56	4.5936	91	5.0826
22	3.6454	57	4.6115	92	5.0936
23	3.6908	58	4.6290	93	5.1044
24	3.7343	59	4.6463	94	5.1152
25	3.7760	60	4.6632	95	5.1258
26	3.8160	61	4.6799	96	5.1363
27	3.8544	62	4.6963	97	5.1468
28	3.8915	63	4.7124	98	5.1571
29	3.9272	64	4.7283	99	5.1673
30	3.9617	65	4.7439	100	5.1774
31	3.9950	66	4.7593	101	5.1874
32	4.0272	67	4.7744	102	5.1973
33	4.0585	68	4.7894	103	5.2071
34	4.0888	69	4.8041	104	5.2168
35	4.1182	70	4.8186	105	5.2264

*Modification of formula given by A. B. Randall and E. S. Crawley, "The Design of Seating Areas for Visibility", *American Architect*, May 21, 1924, Vol. 125, No. 2446, page 487.

An interesting effect is obtained by the shadows on the many planes on the rear of the Walter Strong Memorial Stadium, Beloit College, Beloit, Wis. The seats are concentrated near the center of the field. Allen & Webster, architects; Mogens Ipsen, engineer.

The popularity of football is shown in this view of the stadium at Northwestern University, Evanston, Ill. Even the temporary stands at the ends of the field are filled. The crescent shape and balcony concentrate the permanent seats near the center of the field. The cross section of the seat deck is curved by using variable riser heights to provide equal sight lines for all seats. Original plans call for increasing the capacity of this structure as funds and demands warrant by ultimately providing two balconies on each side of the field. James G. Rogers, architect; Gavin Hadden, engineer.

To provide this curved seating section requires that each riser be slightly higher than the preceding one. Few grandstands have been built to the theoretical curve but a number have been constructed with a series of straight sections which approximate the theoretical curve. This is obtained by increasing the height of riser for succeeding groups of 5 to 10 rows rather than for each row. This greatly reduces the construction difficulties involved in the use of variable riser heights. Such a plan is recommended for structures containing more than about 25 rows of seats and may be used in smaller structures.

Treads and Risers

The seat treads and risers should be as small as possible for the sake of economy, but must be sufficient for comfort and a good view. Increasing the width of tread will, of course, increase comfort by providing more leg room, but it will also reduce the sight line clearance.

Most grandstands have a tread of from 24 to 30 in. A width of 25 or 26 in. gives reasonable comfort and economy and is probably most satisfactory for the average case. Twenty-four inches should be the minimum considered although a very few structures have been built with narrower treads. Where cost is not particularly important, the treads may be as much as 30 in. When seats with fixed backs are used the tread should be at least 30 in. Where there is much movement of the spectators during the program, as at race tracks, the treads must be wider than when the spectators remain at their seats from the beginning to the end of the program, as at football games. More room per seat is also generally provided for baseball games than for football games.

The height of the riser affects the cost and sight lines. Increasing the riser height will increase the total height of the structure and consequently its cost. The sight lines are controlled by the ratio of riser to tread, the sight clearance, and the location of the first seat in relation to the assumed focal point. This is shown by the diagrams and discussion on page 11. Ordinarily the height of riser is the least fixed of these dimensions and varies from 6 to 18 in. However, most of the small stands have risers between 9 and 14 in. The elevation of the first seat should not be any higher than necessary since extra height means extra cost and poorer sight lines.

The first tread should be wide enough to provide 18 in. between the front edge of the seat and the wall or rail. Additional width is not necessary unless a definite cross aisle is required. The distance between the back of the last seat and the rear wall need not be more than 6 in.

Seats and Seat Supports

The space allowed for each seat, lengthwise of the row, is generally between 17 and 18½ in. The 17-in. width should be the absolute minimum and a width of 18 in., which is required by many building codes, is preferable. Even in the same section, the width of seats may be varied slightly to provide for varying total length of rows caused by entranceways, aisles, etc. The height from deck to top of seat should be approximately 18 in.

The seats themselves are usually of wood, nominally 2 in. thick and 8 to 12 in. wide, preferably a minimum of 10 in. The width may be made up of one, two or three pieces, fastened to supports attached to the deck. Seats made up of two or three pieces are recommended since they have less tendency to warp than those made of a single plank. Although many seats are made level, greater

Typical seats and seat supports. Various other combinations or modifications of these typical details may be made to suit personal ideas. Seats may be fastened to supports by bolts or screws and bolts cast in the concrete or expansion bolts may be used to fasten the seat supports to the concrete. The first two supports are applicable only to relatively high risers, but the others may be used with any height of risers.

comfort and better drainage are provided by tilting the seat slightly, making the front edge ½ to 1 in. higher than the back edge.

Douglas fir, redwood and Southern cypress are most commonly used. While No. 1 grade common lumber has given good results, the better grades are generally used. The boards should be free of pitch and should be kiln-dried or air-seasoned before using. Lumber may be treated with preservatives to prolong its life and may be painted for further protection and to reduce the tendency of the upper surface to cup. Protective materials and paints should be selected and applied so that

The popularity of playgrounds is increased whenever small, inexpensive bleachers are provided.

Hampton St. Playground, Holyoke, Mass. A small baseball grandstand with largest number of seats near the home plate. Paul S. Howes, architect; Philip E. Bond, engineer.

Phillips High School, Birmingham, Ala. Precast concrete slabs 4 in. x 16 in. x 5 ft. long were set in the embankment to provide supports for the seats and hold embankment in place. This economical scheme for playground seating is applicable only in mild climates. J. D. Webb, engineer.

Morgan Park, New London, Conn. Riser beams were precast, other members cast in place. George A. Waters and K. H. Holmes, engineers.

Ansonia, Conn. Wood plank seats are supported directly on reinforced concrete stringers. V. B. Clark, engineer.

Simple masses of concrete with texture produced by form boards distinguish the baseball grandstand at Seattle, Wash. William Aitken, architect.

staining of clothing will not occur. Top edges of seat boards should be chamfered or rounded to reduce wear and splintering and to give better drainage. Contact areas between wood members should be avoided wherever possible to reduce deterioration.

Various designs of seat supports have been used, some attached to the risers and others attached to the treads of the seat deck. A few examples of these seat supports are illustrated. In making a selection, consideration should be given to the ease with which the support can be placed in proper position, its interference with cleaning the structure and the opportunity for drainage of moisture away from the metal and wood parts to reduce deterioration. Supports attached to the riser have advantages in these respects. On the other hand some of those placed on the tread are lower in first cost. To reduce breakage of the wood seats, the bracket should give practically complete support across the width of the seat. Supports are placed at about 4-ft. intervals along the length of the seats. The ends of planks may meet over a support, or two supports about 1 ft. apart may be used. Seats should stop or be cut at expansion joints with a support used close to each side of the joint. Where the seat extends less than 4 ft. beyond the joint, the plank may be continuous if not rigidly attached to the end support. Fastening devices driven from the underside of the seat and extending only part way through the wood will reduce the decay hazard. Through bolts are stronger but increase the decay hazard due to the retention of moisture.

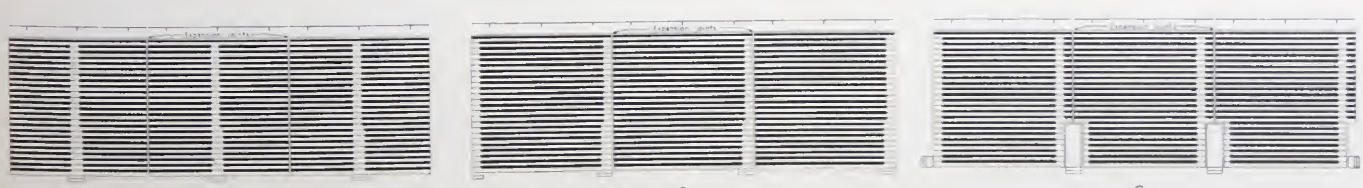
Grandstands for professional baseball games and horse races are generally equipped with individual slat seats with backs. These require more space than the bleacher type of seats and the exact requirements will depend on the design of the seat. Manufacturers of such seating equipment should be consulted for their recommendations for the equipment selected.

Aisles

Grandstands are generally divided into sections by transverse aisles. The sections usually have from 24 to 32 seats per row between aisles. The most favored width appears to be either 26 or 28 seats.

Aisles beside the end walls are sometimes advantageous where they can be connected directly to an entrance but are not essential. The width of one aisle can be saved by placing the first aisle one-half section from the wall.

Widths of aisles vary, but the most common width is



Alternate arrangement of aisles and entrances for 2100-seat grandstands shown on page 24. The solid line at the top shows location of column bents with reference to expansion joints. Note increase in aisle width toward exit. The capacity may be increased in the original construction or at a later date by using additional sections. In Diagram A, all sections are the same. In Diagrams B and C, the center and right hand sections are typical except that instead of the ramp for the right hand section in C, temporary steps are used until the next section is added. The left hand sections of B and C are modified by the use of an extra aisle and special entrance.

Main entrances to the Suffolk Downs Race Track grandstand at East Boston, Mass., are characterized by open cantilever design of stairways. Note division rails on wide stairs. Mark Linenthal, engineer; Blackall, Clapp, Whittemore & Clark, associate architects.

3 ft. This width permits a single file in one direction and an usher going in the opposite direction. In a few cases aisles are 4 ft. wide, permitting two lanes of traffic in the same or in opposite directions. Where there are aisles on both sides of an entranceway, they may be only 2 ft. wide. These widths are considered the minimum advisable to insure sufficient clearance against hazard of clothing catching in the seats or disturbing the occupants of the end seats. Where seat risers are more than 9 in. high, an extra step in the aisle is provided for each seat riser, making each step riser one-half the height of seat riser and each step tread one-half the width of seat tread. Steps should be the full width of aisle.

Longitudinal aisles, whether placed in front of the first row of seats or part way up the stand, are objectionable as the view of spectators back of the aisle may be obstructed. However, where seats are not reserved an aisle at the entrance level will be a considerable convenience to the spectators in choosing their seats, but will interfere with the view of those already seated above the aisle. If the aisle is part way up the stand, the sight lines for the first few rows above it should be investigated for the effect of the extra aisle width.

Entrances and Exits

In the small stands without entrance through vomitories it is preferable to have entrances from the field level at each transverse aisle rather than simply entrances at each end with a longitudinal aisle leading to the transverse aisles. With a small grandstand built on an embankment, entrance can frequently be made at the rear directly to each aisle or to a longitudinal aisle or concourse connected with the transverse aisles.

In the larger grandstands, entrance is made through vomitories. The favored width of vomitory is 6 ft., although many are 8 ft. and some are only 4 ft. Standard requirements for exits are based on traffic lanes of 22-in. width. Widths of vomitories and passageways should, therefore, be in approximate multiples of this width. Handrails extending not more than $3\frac{1}{2}$ in. from the wall are not considered as reducing the effective width of passageway.

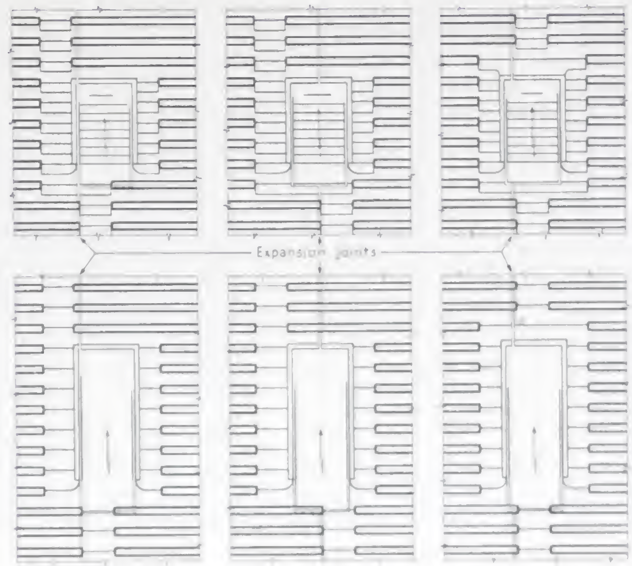
Most building codes specify width of exits in terms of number of seats. For example, if 8 in. is required for each 100 seats, a single vomitory or gate serving a section of 800 seats would require a width of 64 in. However, this should be increased to 66 in. to provide three 22-in. traffic lanes.

Where the seats do not have back rests, many of the patrons will approach the exits by walking over the seats rather than in the aisles. In such cases it is not necessary to have the width of aisles equal to the width of exits, in fact the code requiring the width of exits to be 8 in. per 100 seats permits the aisles to be 6 in. per 100 seats.

The location of vomitories will depend upon the contour of the site and the size of the section served. Where the section served is relatively small, the vomitory can be at the same level as the entrance, thus avoiding ramps or stairs. For larger sections it is advisable to place the vomitory part way up the stand so that it will be served by an aisle below as well as the aisle above. In the very large stadiums, a second row of vomitories is provided to serve the upper sections of the stand.

Stairways and Ramps

Various studies have been made of the rate of egress from stairways and ramps. Some of these indicate average values of about 30 persons per minute per traffic lane of 22-in. width for stairways and about 37 for ramps. Some authorities give higher values, in some cases assuming a rate of egress of 45 persons per minute per traffic lane for both stairways and ramps. On this basis, and assuming that it is desired to exit the entire crowd in 5 minutes, a grandstand seating 10,000 persons will require a total of 45 lane widths of exit ramps, vomitories, stairways or gates directly from the seat deck. This total width must be maintained all the way to the outside of the grandstand and enclosure.

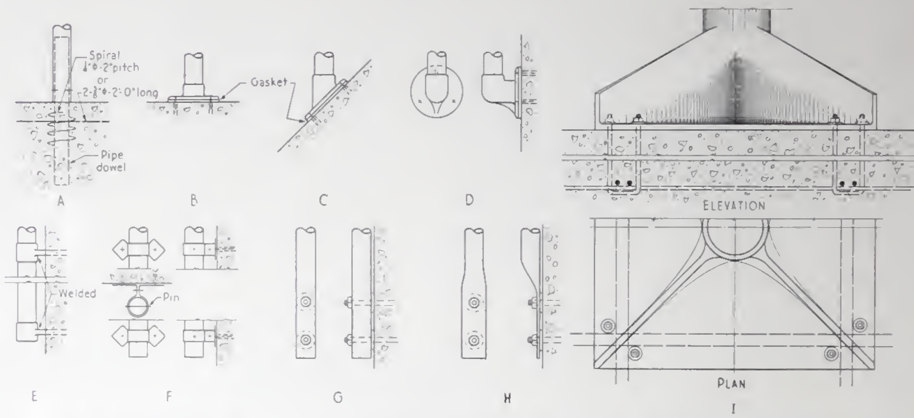


Arrangement of aisles at vomitories. Aisles should be arranged not only to handle the crowds efficiently but to fit the location of the expansion joints, shown by light double lines. With the arrangements of expansion joints shown, the walls around the vomitories are carried on the deck and the ramps or stairs are self-supporting and free from remainder of the structure.

In designing stairways, certain rules are widely used. These require that the sum of riser height and tread width, in inches, shall not be less than 17½ nor more than 18; that the sum of 2 risers and 1 tread, in inches, shall not be less than 24 nor more than 25; that the product of riser and tread, in inches, shall fall between 70 and 75. Risers of 6½ to 7½ in. with treads of 11 to 10 in. are most commonly used and conform to these rules.

Ramps are frequently used, instead of stairs, from

The baseball grandstand at Louisiana State University, Baton Rouge, La. Weiss, Dreyfous & Seiferth, architects; George P. Rice, structural engineer. The stand was designed for future extension at the ends. Cantilevered canopy over ticket windows and main entrance, and the curved fascia girder are interesting details.



Rail and flag pole anchorage. Rail or pole anchorage should be of a type which will securely fasten the rail or pole to the structure but will not cause the concrete to crack or accelerate rusting. Large pipe embedded directly in the concrete, particularly in thin walls, so reduce the section of concrete that cracks are likely to occur. Sketch A shows a short spiral or reinforcing bars inserted to compensate for the concrete displaced by the pipe. Using the small pipe as a dowel rather than a large pipe as a socket, also reduces the tendency to crack the concrete and rust the pipe. Sketches B, C and D show the most common types of standard fittings for railings. Side fastenings such as D through H, where they can be used, have the advantage of increasing the effective width of stairs or passageway and allow water to quickly drain away from the metal. Types E and F are satisfactory for small and medium size flag poles as well as railings. Type I may be used for anchoring base plates for medium or large flag poles or floodlight poles. The details shown of the base itself are not significant. The special stresses caused by wind on medium or large poles must be considered in the design of the supporting structure as well as the fastenings.

ground level to the vomitory. Their capacity to handle crowds is between that of stairways and level passageways, but they are recommended primarily for greater safety rather than for greater capacity. Requirements for building exits often limit ramp slopes to not more than 1 in 10 because of the danger of possible panic from fire or other cause, but since this is less in grandstands than in buildings, somewhat steeper slopes can be used. Ramps as steep as 1 in 4 have been used, although slopes of 1 in 6 to 8 are safer and more commonly used. Ramps are longer than stairways of the same height. They are particularly suitable for grandstands where it is not necessary to make maximum use of the space under the deck and in the very large stadiums of considerable height.

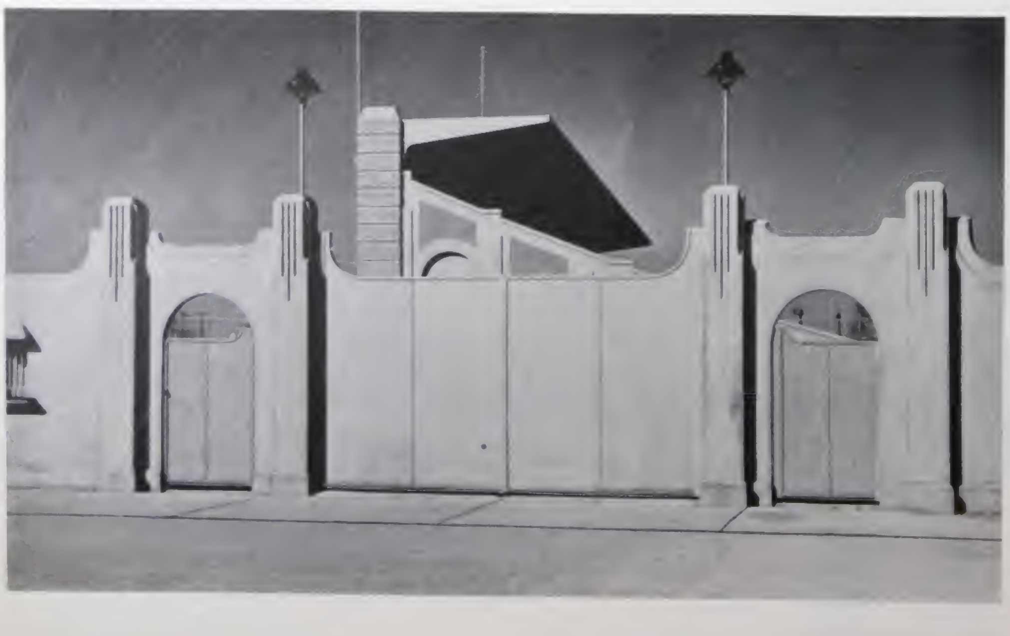
Walls and Railings

Protection at front, back and sides of the grandstand and around entrances may consist of solid walls of concrete or of pipe sections anchored to the concrete. Solid walls in front of the first row are not more than 3 ft. high above the lower tread. A height of 32 in. above the lip of the step is quite often used for handrails on enclosed stairways. For greater safety, rails and walls at ends of stands and around entrances are usually 3 to 3½ ft. above the front edge of the tread. Solid back walls give spectators protection against strong winds and are therefore frequently made higher.

Fences and Entrances

Where admission is to be charged, a fence to enclose the field is necessary. While wire fences have been used on some projects, they do not shut off the view of people on the outside. Many of these spectators would probably pay admission if a solid fence enclosed the field. Those who have paid admissions do not like to know that others are able to view the events without payment.

Attractive fences of concrete, designed and built to



Concrete fences are widely used to enclose athletic fields. They harmonize with the grandstand and are an effective screen. The ticket window and wide exit gate form an integral part of the fence and entrance detail at Strobel Field, Sandusky, Ohio. A front view of this grandstand and cantilever roof is shown on page 30. Harold Parker, architect; R. C. Reese, engineer.

ntrances to the playing field may be of concrete to match the grandstand as at the John Fawcett Stadium, Canton, Ohio. ket offices have been incorporated in the entrance. Charles E. Firestone, architect and engineer.

rmonize with the grandstand structure, can be used to t off the view from the outside. The concrete may be t in place, precast in special large units, or the usual ncrete masonry may be used. Decorative treatment n be given to the fence, and the texture suited to the sign. In some cases an ornamental entrance to the ying field is provided. Such an entrance may be com- ed with the enclosure fence and treated as a separate ucture, or it may be an integral part of the grand- nd structure. Ticket booths may be incorporated in e entrance.

ates in entrances, fences or enclosure walls should be arranged that a single file of the crowd going in passes ch ticket collector. However, to provide quick, unob- ucted passage for exit of the crowd, it should be pos- ble to throw the gates wide open. The accompanying strations show a few entrances and fences as ex- mples of the suitability of concrete for these structures.

umination for Night Play

Baseball, softball and football played at night are at- cting large crowds of spectators. A high level of mination is required, so distributed that the field and e ball as it flies through the air can be seen clearly from l positions. Requirements of spectators as well as yers must be considered. The minimum illumination ll depend on the game to be played; the class of event, at is, whether major or minor league, professional or mateur; and size of audience. As the number of spec- tors increases the illumination must be increased as e farthest-away spectators have to see from a greater tance.

The best results are secured with modern, efficient floodlights used in accordance with sound principles of lighting as recommended by the National Electrical Manufacturers Association*. Engineers thoroughly familiar with these requirements and experienced in this work should be engaged to plan the installation.

Groups of floodlights are placed on poles or towers. For covered grandstands, all or part of the lights can be placed on the roof if this is designed to carry the extra load. Light poles in front of the grandstand interfere with the view of the spectators. Placing them farther back requires only a few additional lamps and little additional power, generally not more than about 5 per cent additional. The lamps, however, must be placed higher as the distance from the field increases. For example, the recommended height for poles set 20 ft. from the sidelines of a standard football field is 45 ft., and a height of 95 ft. is recommended where they are set 120 ft. from the sidelines, with heights in direct proportion for intermediate positions. To compensate for the greater height of poles, fewer of them are necessary. When the lights are placed at distances of 30 ft. or less from the sidelines of football fields, 5 poles are usually required on each side of the field. When placed 75 ft. or more from sidelines, only 3 poles are required on each side.

In some of the newer grandstands suitable bases are provided at the upper edge of the deck on which towers are erected for mounting the floodlights. Thus good lighting is provided without obstructing the view of any spectator, and at the same time the lighting facilities are made an integral and harmonious part of the structure.

**Standards for Floodlight Distribution Curve and Layout for Outdoor Sports* issued by National Electrical Manufacturers Association, 155 East 44th St., New York, N.Y.

Space under the grandstand at West Carrollton, Ohio, is used for the storage of school buses. Simple ornament cast in the concrete by the use of molds in the forms adds to the attractiveness. The toilet fixtures are vented through the cross-fitting on the flag pole. Rial T. Parrish, architect and engineer.

Public Facilities

Public toilets should be provided in practically all cases. One authority estimates that the following fixtures are required: for each 1,000 men, 1 water closet and 6 urinals; for each 1,000 women, 7 water closets. In some locations, building codes require public toilets and specify minimum requirements. For example, one city requires for the women's toilets, 1 water closet for each 800 seats, and for the men's toilets, 1 water closet for each 675 seats, and 1 urinal for each 200 seats. These requirements are for baseball and other athletic grandstands. For larger stadiums to be used for a variety of purposes the same code requires for the women's toilets, 1 water closet for each 600 seats, and for the men's toilets, 1 water closet for each 750 seats and 1 urinal for each 225 seats. The same code requires at least 1 lavatory in each toilet room. It also makes mandatory the installation of drinking fountains, at least 1 for each 2,000 spectators. The fountains are not to be placed in toilet rooms and are to be so located that the horizontal distance to be traveled by any spectator in reaching them shall not exceed 400 ft. In the large grandstands several toilet rooms should be provided to make them easily accessible. All toilet rooms should be well lighted and ventilated and designed for easy cleaning.

Concessions

Booths for refreshments and other concessions are often the source of extra income at well patronized grandstands besides being conveniences appreciated by the public. They are often of a temporary nature, especially at football grandstands, consisting of wood counters placed between columns under the deck. Portable equipment furnished by the concessionaire is usually used, but electrical outlets and waste sink with drain as well as a water supply should be provided. A small storage room in back of the booth is sometimes provided. In grandstands that are used more frequently, such as the professional baseball grandstands, more permanent construction should be provided and sufficient space allowed for servicing the vendors of refreshments who distribute these throughout the stand.

Ticket Booths

Ticket offices or booths are usually placed at or near the main entrances. They should be so placed that they are convenient but do not interfere with the entry of those holding tickets purchased in advance. A booth for one ticket cashier may be as small as 3 ft. square.

Offices and Storage

Space under the grandstand can be used for offices of the operating management, the athletic departments of schools, or for other purposes. Closed-in storage rooms for athletic equipment, janitor's materials and groundkeeping equipment are often desirable. The sizes of these rooms will, of course, depend on how they are to be used, but are generally determined by the space remaining after providing adequately for the more important facilities previously discussed.

Press and Broadcasting Accommodations

Schools and colleges have come to realize the great value of favorable publicity and friendly relations with the public. Commercialized sports, such as professional baseball and football, have appreciated this for a long time and make adequate provision for representatives of the press and for radio broadcasting. Suitable provisions for these services have been neglected in many instances, or have been added after the main structure

Hollow concrete units form the enclosure of this concession space under the grandstand at Mooseheart, Ill. The cast-in-place concrete lintel has a simple and inexpensive decorative treatment. The plaques are of cast stone.

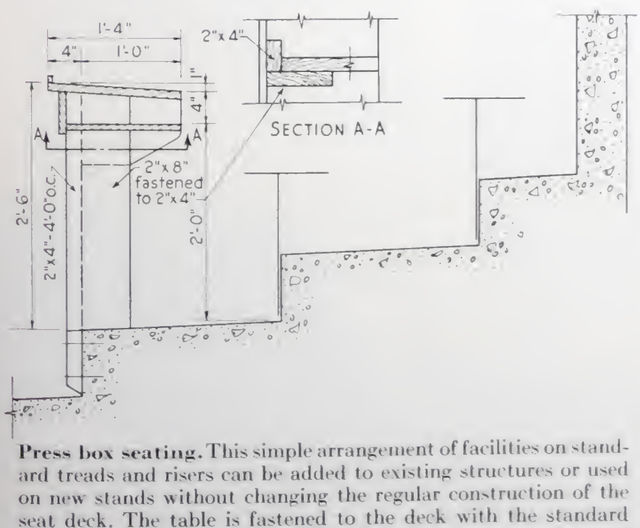
was erected, sometimes resulting in more or less makeshift accommodations out of harmony with the rest of the structure. Provision for these accommodations should be made in the original design, and the construction should be permanent and fit into the general scheme. The space should be covered and preferably enclosed with movable plate glass windows on the front. Double glazed windows hinged at the top to swing outward are recommended.

For football grandstands these facilities should be centered on the 50-yd. line and are generally at the top of the stand. They should be so elevated that the reporters' view will not be obstructed by a standing crowd. For baseball grandstands these facilities should be located near home plate. If the stand is roofed, the press box may be suspended from the roof near its front edge, otherwise it should be at the rear.

The space and equipment for reporters and broadcasters will depend upon local conditions such as the importance of the contemplated events and the number of press representatives and broadcasters expected.

The minimum facilities should be a continuous desk about 18 in. wide with an allowance of 2 lin.ft. per man. Where a wire report is being sent, the reporter and his telegrapher will need at least 4 lin.ft. of desk as well as proper telegraphic connections. Some representatives telephone their reports to their offices either during or immediately after the game, so consideration should be given to furnishing the necessary facilities. Telephone connections with the players' bench and scoreboard are also desirable. Electric lights should be provided and some form of heating is desirable.

The size and equipment of broadcasting booths will also vary with the importance of the contest and the size of staff. Generally accommodations should be provided for 2 engineers with their equipment and the announcer with 2 or more assistants. This requires a minimum room about 10 ft. long and 8 ft. deep. The furnishings should consist of a table across the entire front for the announcer and his assistants, another table about 3 ft. square for the engineers, and 6 or more chairs. Where the broadcasting will be done by only a small local station, the personnel may be less and the booth proportionately smaller. The booth should be soundproofed to prevent interference from outside noises and the inside should be acoustically treated. Adequate ventilation must be provided.



Press box seating. This simple arrangement of facilities on standard treads and risers can be added to existing structures or used on new stands without changing the regular construction of the seat deck. The table is fastened to the deck with the standard seat support attachments. An enclosure or at least a roof should be provided.


The press box of architectural concrete is an integral part of the grandstand at Coatesville, Pa. The wide windows provide a good view of the playing field and there are few seats having an obstructed view. Lawrie & Green, architects and engineers.

One very important item to be considered is the adequacy and location of electric, telephone and radio lines. There should be several electric outlet receptacles for power and heat as well as the electric lights. In addition to the outside telephone and telegraph connections, there should be lines to the players' bench, scoreboard, and other points from which special items of interest may be broadcast. The lines should be in lead cables in weatherproof conduit. To prevent interference the cables for radio, telephone and power lines should be in separate conduits.

Because of variations in equipment and local conditions officials of the broadcasting, press, telephone and telegraph organizations who are expected to use these facilities should be consulted regarding the exact layout and equipment.

Public Address System

A public address system is desirable for announcements during the progress of a game and particularly for entertainments in which there is speaking or singing. Permanent lines should be installed from the loud speakers to convenient outlets near points of interest on the field and in the press box or broadcasting booth.

STRUCTURAL DETAILS

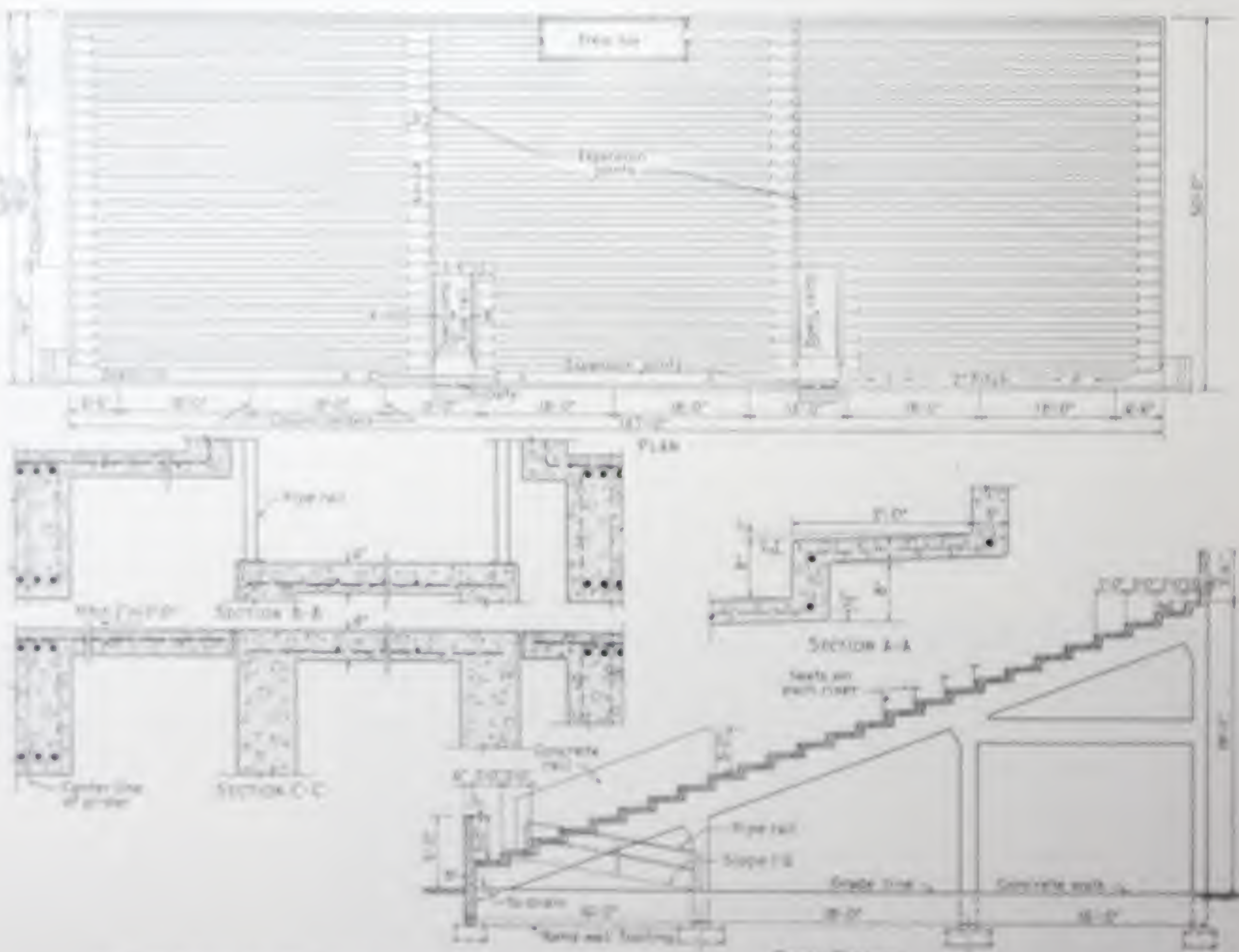
Loads

Grandstands are ordinarily required to be designed for a live load of 100 lb. per sq.ft. of horizontal projection. Investigations have shown that the mass and rigidity of reinforced concrete grandstands are such that stresses due to impact and wind load may safely be neglected in single deck structures.

Framing

With very few exceptions, grandstands are designed as a series of transverse bents supporting the seat deck. The bents consist of a sloping girder supported by columns on the necessary footings. Where the height of columns exceeds about 15 ft., it is usually desirable to use cross struts to reduce the unstayed height and to generally stiffen the bent. The selection of the size and reinforcing of these struts is primarily a question of engineering judgment rather than of analysis. The bars should extend through or be hooked into the columns. Although the stiffness may be increased by using fillets or haunches at the juncture of columns, girders and struts, the additional expense is not ordinarily justified except where such members intersect at an acute angle. The bents are held together longitudinally by the seat deck. Longitudinal struts, similar to those in the bents, should be provided to reduce unstayed column heights and add rigidity.

The deck is designed with the riser acting as a beam between the sloping girders and the tread as a slab spanning between risers. In most instances the underside of the deck is stepped the same as the top although



Typical design for 2100-seat grandstand. The capacity may be increased by adding sections, each seating 700.

a few stands have been built in which the underside of the deck is a plane surface.

In designing the risers consideration should be given to using continuous straight bars in both top and bottom. This will require slightly more steel than where trussed bars are used but the unit steel cost will be less, construction will be simplified, and the steel will be more effective in reducing cracking due to volume change. The splicing should be at the center of span for the top bars and at the support for the bottom bars.

The spacing of columns and bents will depend upon local conditions such as total width and length of stand, use of space under the stand, location of entrances, architectural treatment and minimum practical size of members. Generally the spacing is about 16 to 20 ft. Some economy may be obtained by making end spans slightly shorter or using a short cantilever end span.

Expansion Joints

Grandstands should be divided into convenient lengths to allow for the movement caused by changes in temperature and moisture content. The proper location and spacing of expansion joints must be determined for each job and since there are no fixed rules for this determination some general comments will be helpful. Expansion joints should be placed where there is the greatest tendency for the structure to crack, such as where the section is reduced at vomitories and other openings. These joints are ordinarily spaced about 60 ft. apart.

Expansion joints must be made so that movement in them can easily take place. Joints in which there is friction between the moving parts have not proved entirely satisfactory and are not recommended.

Completely open joints are preferable where leakage through the joints will not interfere with use of the space under the stand. The best location of these is between cantilever spans. Here it is advisable to finish the seat deck with small edge beams, the undersides of which form a plane surface. This construction prevents any water that comes through the joint from running back along the underside of the seat deck, thus causing discoloration and possibly more serious trouble. With these joints, the deck can be made watertight either when originally built or at a later time by fastening a trough tightly against the edge beams either by bolts cast in the concrete or by expansion bolts. These troughs should be connected at the bottom to a drainage system. To protect the drainage system from debris, a small catch basin type of fixture should be provided at the bottom of the trough. These fixtures should have handholes so that they can be cleaned easily.

Probably the most common method of making an expansion joint watertight is to provide a crimped copper dam across the joint with an elastic material above and sometimes below it. In constructing such joints, particularly where the joint is sloped as in seat decks, it is important that the crimped portion not be filled or blocked by concrete or joint filler. With this space open, any water which passes the joint filler will be caught by the dam which will act as a trough to discharge the water at the bottom. However, if this trough is blocked by concrete or joint filler, a considerable head of water may develop above the stoppage and leaks occur.

Waterstops or dams are usually made of 16 oz. copper. One-half-inch diameter holes at 8-in. centers punched near the edges of the strip will aid in securely anchoring it in the concrete. The dam must be so placed that the concrete will embed it securely.

These construction views show some of the unusual reinforced concrete framing of the 100,000-seat stadium at Buenos Aires, Argentina. José Aslan and Hector Ezcurra, engineers.

Western State Teachers College at Kalamazoo, Mich., owns this attractive concrete grandstand. The horizontal rustication strips add interest to the surfaces and provide locations for hidden construction joints. Note location of ticket windows at entrances. A smaller stand is on embankment on opposite side of field. Osborn Engineering Co., architect and engineer.

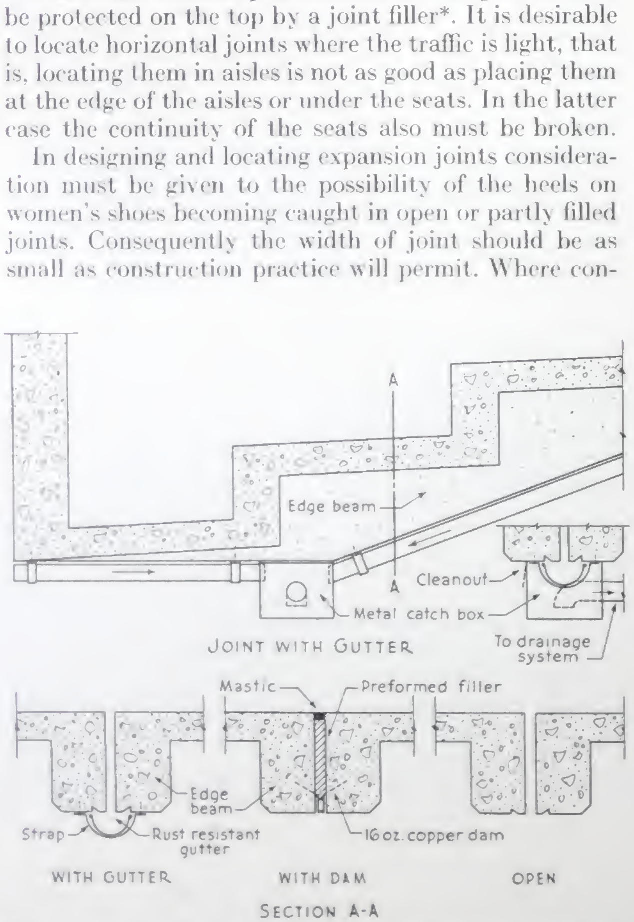
Where the waterstop is horizontal or sloped, it must be protected on the top by a joint filler*. It is desirable to locate horizontal joints where the traffic is light, that is, locating them in aisles is not as good as placing them at the edge of the aisles or under the seats. In the latter case the continuity of the seats also must be broken.

In designing and locating expansion joints consideration must be given to the possibility of the heels on women's shoes becoming caught in open or partly filled joints. Consequently the width of joint should be as small as construction practice will permit. Where considerable traffic will occur over a joint, it may be desirable to install a sliding metal plate over the joint.

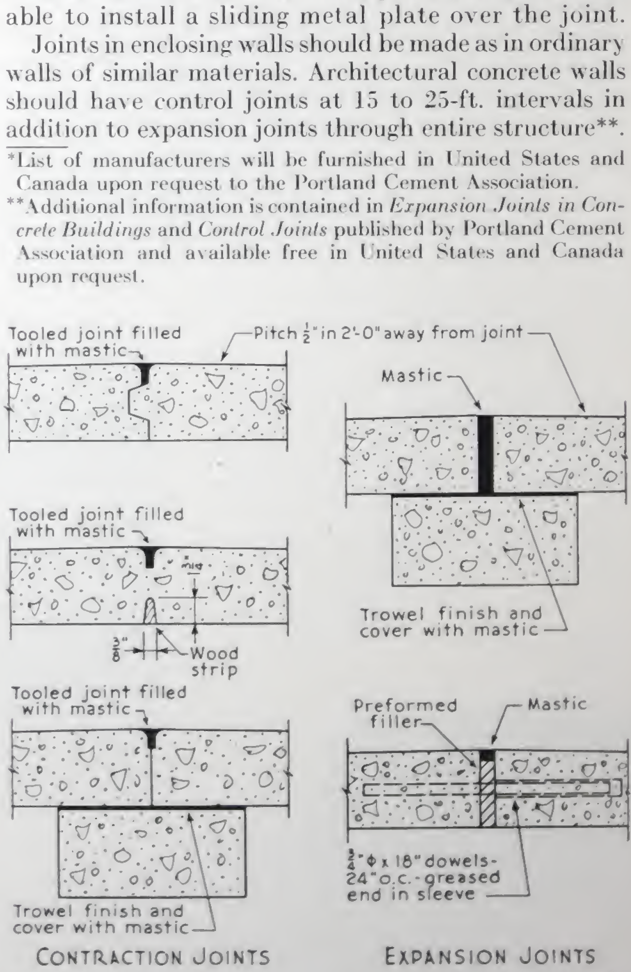
Joints in enclosing walls should be made as in ordinary walls of similar materials. Architectural concrete walls should have control joints at 15 to 25-ft. intervals in addition to expansion joints through entire structure**.

*List of manufacturers will be furnished in United States and Canada upon request to the Portland Cement Association.

**Additional information is contained in *Expansion Joints in Concrete Buildings* and *Control Joints* published by Portland Cement Association and available free in United States and Canada upon request.



Expansion joints in deck. The seat deck is finished with a small edge beam on each side of the expansion joint. The joint may be made watertight by use of a gutter or a copper dam with joint filler. A catch box is essential with the gutter type. A water drip should be provided along the edges of the beams for the open joint or the joint with gutter.



Expansion and contraction joints in slab or deck on ground. Both expansion and contraction joints must be detailed to be watertight and to keep the two sides in line. The expansion joints must also provide for easy movement.

Construction Joints

Since the amount of concrete between expansion joints is frequently more than can be placed in one day, construction joints will often be necessary. The location and construction of these joints, particularly in the deck, are of considerable importance.

There are two procedures commonly used in scheduling the placing of concrete. Each system has its advantages and advocates. In both systems the footings and columns are placed up to the underside of the sloping girders but from there on the order of placing is different. In the first system the entire height of the deck and its supporting girders are placed in one day with the construction joints parallel to the bents. These construction joints are usually placed over the center of the girders, although they are sometimes made near the center of span between bents. In either case, a groove should be made at the joint in the tread and this groove later filled with plastic material.

In the second system all the girders between two expansion joints are placed before any of the deck is cast. The deck is then placed in sections the full length between expansion joints, making any necessary construction joint in a riser. One of the advantages of this system is that the construction joint can be made in any riser and thus the amount of concrete placed at one time can be varied to suit any emergency, whereas in the first system it is important that all the concrete in a predetermined section be placed continuously. The construction joint in a riser should preferably be made at the underside of the tread. The joint should be made straight (by use of a 1-in. strip temporarily tacked to the face form), the surface swept with a stiff broom or otherwise treated to roughen it and remove any laitance and then soaked just prior to placing the next concrete*.

Watertight Decks

Decks should be watertight, at least between expansion joints, even though it is not planned to use the space under the stand. This may be assured by attention to a few details of design and construction. The entire deck should have a definite slope toward the front so that it will drain rapidly. To obtain this effect, each tread should be sloped about 1 in. toward the front. The water from the deck should be collected at the bottom and discharged into a suitable drainage system. Simply discharging the water onto the field is not satisfactory except in small structures with only a few rows of seats. In large structures it is advisable to collect the water at intermediate points in the deck height so that it may be removed more quickly and excessive amounts of water will not flow over the lower treads. As an average, 1 sq.in. of drain pipe should be provided for each 300 sq.ft. of deck.

To reduce the amount of water flowing over expansion and construction joints, the treads are sometimes pitched away from the joints. This may be done by a $\frac{1}{2}$-in. increase in the thickness of the tread made gradually over a distance of 2 or 3 ft. on each side of the joint.

With good quality concrete and reasonable care in design details and construction, the deck can be made watertight so that the space beneath may be used without other protection. However, in a number of instances only a portion of the space has been used so that a standard type of roof has been installed over the rooms to reduce the ceiling height or as protection from the unenclosed area above.

---

*Additional information is contained in *Bonding Concrete or Plaster to Concrete* and *Construction Joints* published by Portland Cement Association and available free on request in United States and Canada.

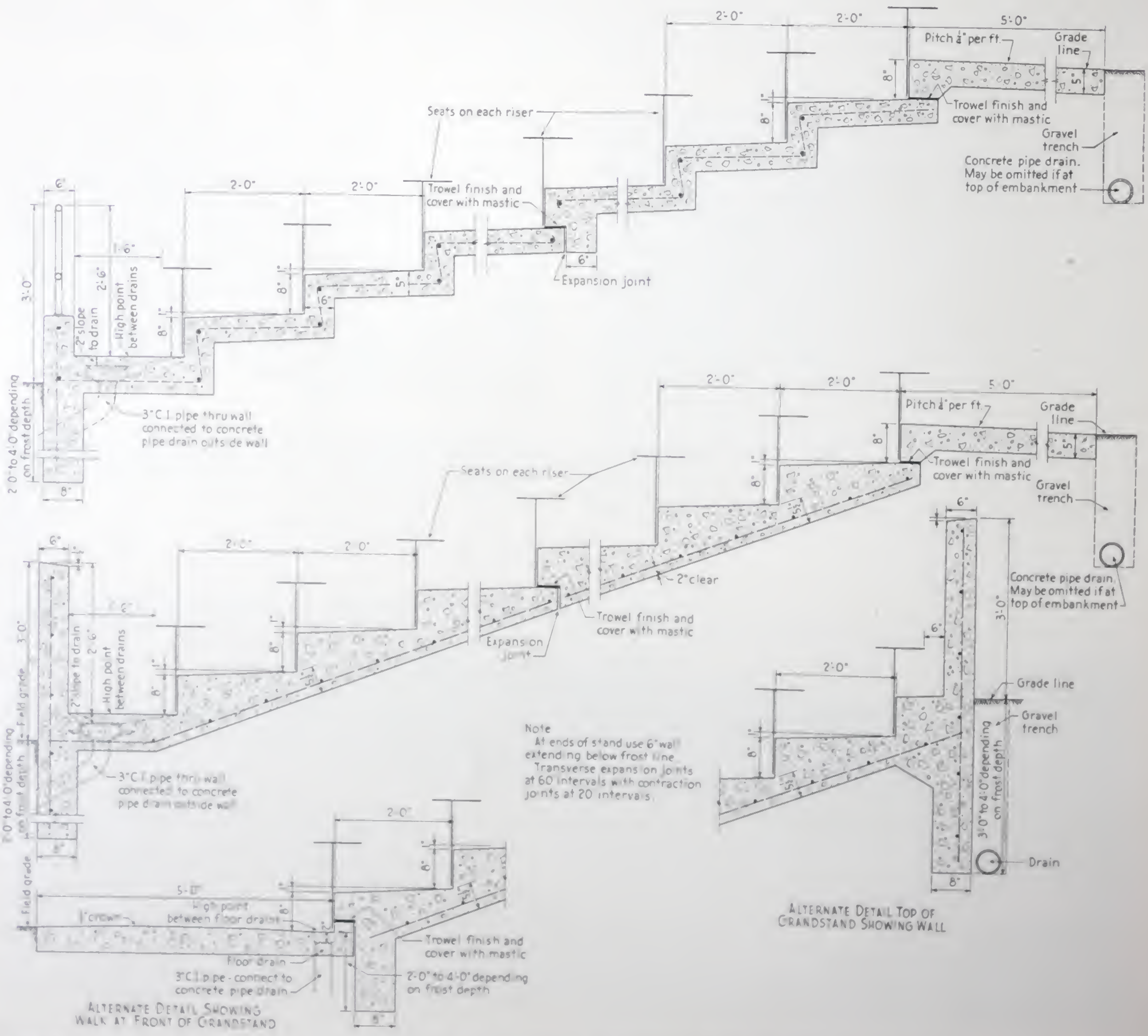
The grandstand at Nyack, N. Y., was built on an embankment, with a passage at one end to a dressing room. To permit winter construction, a heated enclosure covering one section was used and moved on rollers as construction progressed. Henry G. Emery and George N. Schofield, associated architects; Harvey Polhemus, engineer.

Structures on Embankment

Where the topography is such that the seats can be built on an embankment, the construction costs may be reduced. However, some of the saving in cost of the seating structure is offset by loss of the usable space under the seats. Except for very small structures or for those adjacent to existing gymnasiums or similar buildings, space must be provided under the seats or in adjacent buildings for the facilities previously discussed.

There is considerable variation in the general types of grandstands built upon embankments. One type is practically the regular framed structure, simply having short columns supported on the embankment. The only saving with this type is in the shorter columns and less bracing. At the other extreme is the solid slab cast on the plane surfaced embankment. Between these two types are many variations, the choice depending on local conditions such as type of soil, climate, pitch of seats, available equipment, and relative cost of materials and labor. An intermediate type which has been used when the soil is quite firm consists of the concrete deck cast on the soil, which has been cut in the form of steps parallel to the top surface of the stand.

The greatest economy will be obtained by designing these structures simply as slabs supported directly on the ground. However, where built upon a poorly con-



Typical designs for grandstand on embankment. The two general schemes are shown in which the deck is cast on an embankment cut as steps or cut as a plane. The alternate details of front and back are applicable to either general scheme.

The natural site permitted this grandstand at Anniston, Ala., to be built on an embankment. Entrance is from the top. Note the curved back which gives larger percentage of seats opposite the centerline. A small, well located press box is provided. Side walls are appropriately low for the hillside location. R. L. Kenan and Associates, engineers.

solidated embankment, the structure may have to be built on walls or columns extending to good foundations, thus neglecting the supporting power of the soil under the seats and using it only to save the cost of formwork.

Regardless of the type of structure used, it is important to reduce to a minimum the water entering the embankment. Surface water should be intercepted and drained away before reaching the structure. Unless the top of the stand is at the top of the embankment, a cutoff wall and drain tile should be provided at the top of the structure. Drains should be placed at the bottom of the slope also.

Roofs

In general, roofs are not provided on grandstands used primarily for football and track but are provided over at least a portion of stands used for horse races and professional baseball.

In designing roofs every effort should be made to eliminate or reduce to a minimum the interference to spectators' view caused by supporting members. Cantilevering all or part of the roof removes or reduces this interference. The sweeping lines of reinforced concrete cantilever roofs add to rather than detract from the appearance of the entire structure. Also, such roofs are firesafe and do not require periodic painting.

The grandstand at Fraser Field, Lynn, Mass., is placed so that entrance at top of stand is made by short ramps from street level. A wide circulating aisle is provided in back of seats. The cantilevered concrete roof covers a large part of the stand. Note elevated press box under roof. C. R. B. Harding, engineer.

CONSTRUCTION

Quality Concrete

In grandstands a very large surface area is exposed to the destructive forces of weathering. Therefore, not only is correct design essential, but good quality concrete work is necessary to produce a structure that will successfully resist the elements and continue indefinitely to present a pleasing appearance. Specifications for the work should be carefully prepared and supervision of the construction should be competent to see that the specifications are observed.

The technique of concrete making has been developed to such a degree that structures can now be built with assurance they will give long life service with a minimum of maintenance. The quality of concrete is dependent on the characteristics and proportions of the materials, and on the care used in placing and curing.

All materials should comply with the standards of the American Society for Testing Materials.

The resistance of concrete to weathering and its watertightness, strength and other qualities are largely established by the proportion of water to cement*. For grandstands in the northern latitudes of the United States it is recommended that the water content does not exceed 6 gal. of water per sack of portland cement. In the southern states it may be increased to 7 gal. per sack. These amounts include any free surface moisture introduced with the aggregates, for which a correction must be made.

The proportions will depend on the grading of the materials, method of placing and the shape of the section to be placed. It is important that the concrete mixture be of a plastic consistency that can be placed easily, but will not allow segregation of the materials and excess water to accumulate in the corners and on the top surfaces. Such segregation often results in stone pockets, and edges and top surfaces that have poor resistance to weather.

Methods of placing concrete should be chosen that will maintain uniformity in the mixture and produce a completed structure of uniformly high quality. In some cases concrete has been distributed by chutes from a central tower. When necessary to carry concrete over long distances there is a tendency to use chutes on too flat an angle (less than 1 vertical in 3 horizontal) to avoid an excessively high tower. This practice should be discouraged as it requires a very wet or "sloppy" concrete and results in almost certain segregation of the materials and poor weather-resistance in the finished structure.

*Additional information is contained in *Design and Control of Concrete Mixtures* published by Portland Cement Association and available free in United States and Canada upon request.

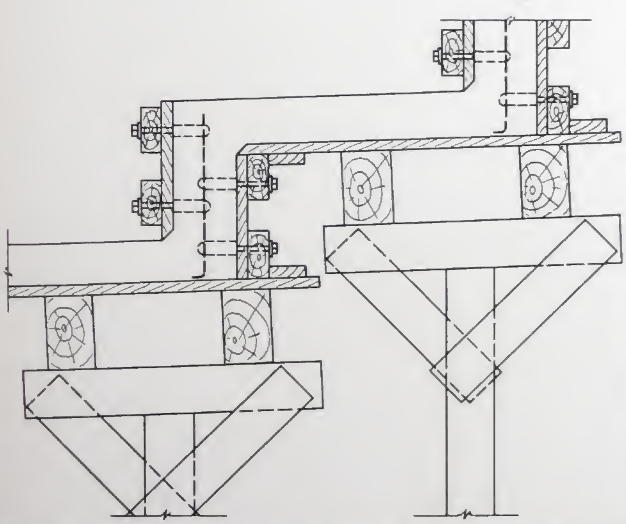
A feature of the grandstand at Strobel Field, Sandusky, Ohio, is the concrete cantilever roof. Note the long dugouts, enclosed press box and location of aisles at one side of vomitories. Harold Parker, architect; R. C. Reese, engineer.

Placing concrete in the seat deck. Concrete is placed from a bucket handled by a crane. This permits direct placing at the desired location in the forms without chutes, an important step in the prevention of segregation of the ingredients and in producing uniform concrete. The forming shown in sketch below is being used with loose planks on supports tacked to riser forms.

Men on upper plank are spading and rodding concrete into place. The fourth tread is being screeded to proper pitch while second tread is being troweled lightly. Treads were later given a light brooming. The supports and planks provide a good working platform with a minimum of interference in the finishing operations, thereby speeding up the work and improving the finish.

Most engineers prefer that the concrete be carried in buggies or in bottom dump buckets handled by cranes to spot the bucket in the exact position for deposit of the concrete. When buggies are used, they are pushed over runways and short lengths of chutes are used from the runway to the forms. Chutes should discharge the concrete into hoppers and not directly into the forms. Both buggies and buckets have the advantage of keeping the concrete in small batches in which there is less tendency for segregation before it arrives at the point of deposit in the forms. The smaller batches can be placed in the forms in the desired locations so that little movement is necessary after the concrete is deposited. Whatever methods of transporting and placing are used every precaution should be taken to maintain the concrete in a uniformly plastic mixture.

When concrete has been placed in the forms it should be thoroughly puddled or vibrated to compact it, to thoroughly embed all reinforcing steel and fixtures and to provide smooth surfaces along the forms. The order of placing concrete will depend on the design and personal preference as discussed on page 27. Particular attention should be given to placing concrete in the deck slab as it will be exposed to the most severe conditions. Placing in the deck is started on the lower tread and riser, from one end to the other of the section. Concrete is then placed in the second tread and riser beginning at the same end of the section as before. This procedure is carried on continuously from bottom to top of the section. The rate of placing



Deck forming. This sketch shows one of the best of the many methods of forming the underside of the seat deck and the risers. The deck forming is simple to erect and strip so that several reuses can be obtained. It can be used with various other types of front riser forms including that shown to the right. The large stringers permit a wide spacing of T-shores. The special form tie also serves as a means of attaching the seat supports, the bolts in the front being replaced by permanent bolts through the seat support. Beveling the front riser form as shown provides a small fillet and makes finishing easier than beveling the opposite way.

This form assembly is made in movable units with 12-ft. plank stringers and riser forms. The units are fastened together with the scabs marked *F*. The units must be carefully anchored in place. Note the 2x4 struts at the lower end of each stringer and the tie wires to the seat support bolts. The tops of the stringers are supported on and tied to the forming for the underside of the deck. A plywood facing with open backing is frequently used in place of the kerfed plank riser form shown.

Texture was produced on the concrete walls of the grandstand at Iola, Kan., by accentuated joints between form boards. Incised lettering was cast above the main entrance. Gerald Griffin, architect.

should be fast enough to avoid the formation of joints between successive steps but should be slow enough so that the concrete can be thoroughly puddled into the forms and around the reinforcing steel.

Reinforcement should be carefully placed and firmly held in position during placing of the concrete. It is especially important to keep the reinforcement away from exposed surfaces. A point where very careful placing is necessary is at expansion joints. Where copper dams and premolded filler are used in the joint, care is required to maintain proper position of the dam and filler and to embed the wings of the dam thoroughly in dense concrete. The concrete should be carefully tamped into place in these locations. No concrete or mortar should be allowed to flow into the joint as this would interfere with its operation.

Proper curing is one of the most economical means of improving the quality of concrete. By proper curing is meant the provision of conditions favorable to hardening of the concrete, namely: (1) temperatures above 50 deg. F. and (2) prevention of too rapid drying of the concrete. Leaving the forms in place is very helpful in retaining moisture in the concrete. All exposed surfaces should be kept continuously moist for at least 5 days, except that for high early strength portland cement concrete moist curing may be reduced to 2 days. In cold weather construction, necessary precautions should be taken to protect the new concrete from low temperatures*.

Finish

Tie wires passing through the concrete should not be permitted in grandstand construction. Form ties should be of a type that is entirely removed from the concrete or leaves no metal closer than 1½ in. to the exposed surface. Holes left by ties should be filled solid with mortar before other finishing or cleaning operations.

With good form construction and careful placement of the concrete, attractive surfaces can be obtained which require no other treatment than knocking off an occasional small fin and suitable cleaning. Plywood and wood-fiber board are widely used as sheathing or lining for forms to produce pleasingly smooth surfaces. Since these materials are available in large sheets, there is a minimum of joint markings from the forms and these can be fitted into the architectural design or can be practically eliminated if desired. A wide variety of rougher textures can be produced by using lumber of different kinds, sizes and finishes*.

Walkway surfaces which include ramps and stairs should be given a nonslip finish. One method of doing this is by floating and troweling the surface, then brooming it. A fiber or bristle broom can be used depending on the texture of surface desired. If the treads of the seat deck are to be broomed, this should be done across the width of tread as broom marks parallel to the length may interfere with quick drainage from the treads. Care must be taken to maintain the specified slope from back to front of these treads for good drainage.

ACKNOWLEDGMENTS

The same details have been used so frequently on more than one grandstand or by more than one designer that it is impossible to know who is responsible for their original use. The details shown have been taken, with some modifications, from drawings kindly furnished by many architects and engineers, to whom the Portland Cement Association expresses appreciation.

---

*Additional information is contained in *Concreting in Cold Weather* and *Forms for Architectural Concrete* published by Portland Cement Association and free in United States and Canada upon request.

Printed in U. S. A.

S-30—15M—12-40

4

[illegible]

T